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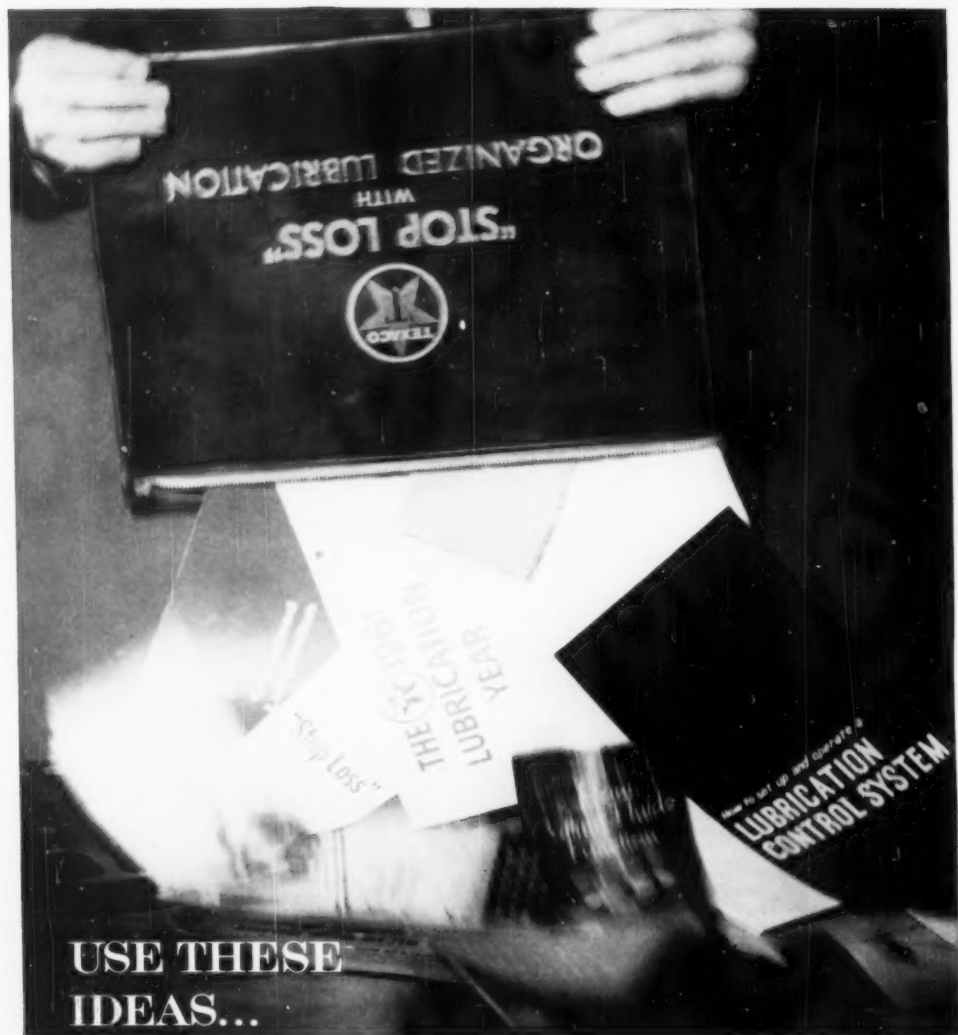
A Technical Publication Devoted to
the Selection and Use of Lubricants

This Issue

**FLEXIBLE
COUPLINGS - II**



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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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FLEXIBLE COUPLINGS—II

IN view of the complexity and extent of information on Flexible Couplings, this article is divided between the October and November 1961 issues of this publication.

SPECIAL APPLICATION COUPLINGS

Over the years a number of flexible couplings have been developed for certain special applications where features have been incorporated in addition to the normal function of a flexible coupling. These additional features might provide some protective device or increase the utility of the flexible coupling. It might be mentioned that although some of the special design couplings were developed for a specific installation or type use they later became essentially standard stock items due to their being adaptable for a variety of installations and applications.¹⁰

The following sections will briefly describe some of the more interesting special design couplings that have been developed and are available from certain manufacturers.

Shear Pin

As illustrated in Figure 22A, this coupling incorporates a single shear pin as the weakest member so as to provide protection against overloading and breakage in other parts of the drive line. The shear pin is made to shear at a pre-determined load and the coupling is designed so that the pin is easily replaceable.

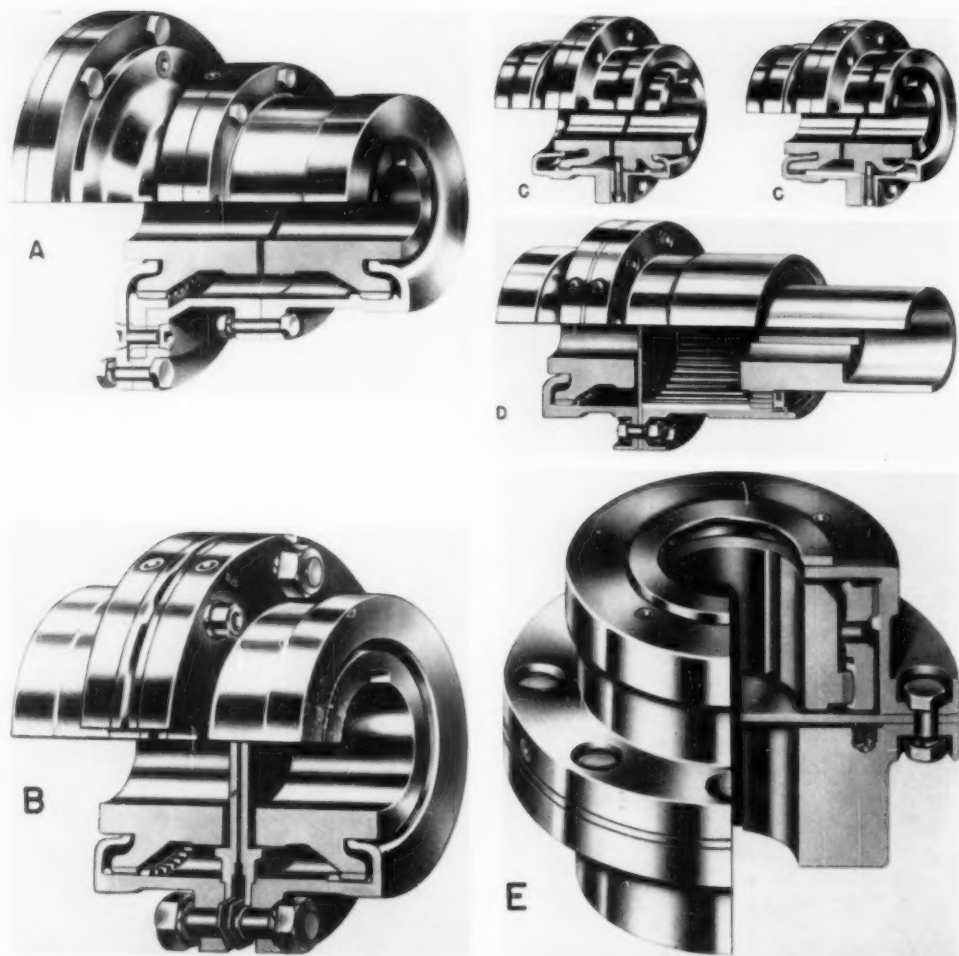
Shear Bolt

An example of this type coupling is illustrated in Figure 22B. Bolts, in this case 4, have a necked down cross section to provide the weakest link in the system. As in the case of the shear pin coupling it protects against overload and breakage of other more costly parts of the equipment or parts that are more difficultly accessible and require longer down time for replacement. This type coupling usually also has provision for rotation of one member relative to the other without damage after the shear bolts have broken.

Disengaging Type

As illustrated in Figure 22C this coupling provides a simple means for engaging or disengaging a coupling. This is accomplished by loosening a screw and sliding the external gear sleeve either to the engaged position shown at the left, or the disengaged position, shown on the right. The screw is then tightened to again hold the sleeve in the desired position. This type of coupling provides considerable saving in time for installations where frequent disengagement of the driving and driven units is necessary as on dual or tandem drive machines. For example, a typical application occurs where a piece of equipment is normally driven by a steam turbine but an electric motor is also connected to its other end for emergency stand-by use.

In another design illustrated in Figure 29 engage-



Courtesy of Koppers Co., Inc.

Figure 22 — Gear coupling types: (A) shear pin; (B) shear bolt (C) disengaging (D) high axial movement (E) vertical operation.

ment and disengagement is accomplished by moving the outer gear sleeve by means of a suitable shift lever and ring arrangement.

Axial Movement Type

Some equipment has driven shafts for which large axial or end movement must be provided. An example is the Jordan type machine used in the paper industry. In this type machine the working element is of conical plug shape running inside a conical shell. Large end movements of the plug shaft are necessary for adjustment during operation and also to compensate for wear. For this purpose a special gear type coupling illustrated in Figure 22D has been developed wherein the outer gear sleeve

is sufficiently long to permit considerable movement of the internal hub gear. In some instances the coupling can compensate for axial movements up to 14 inches.

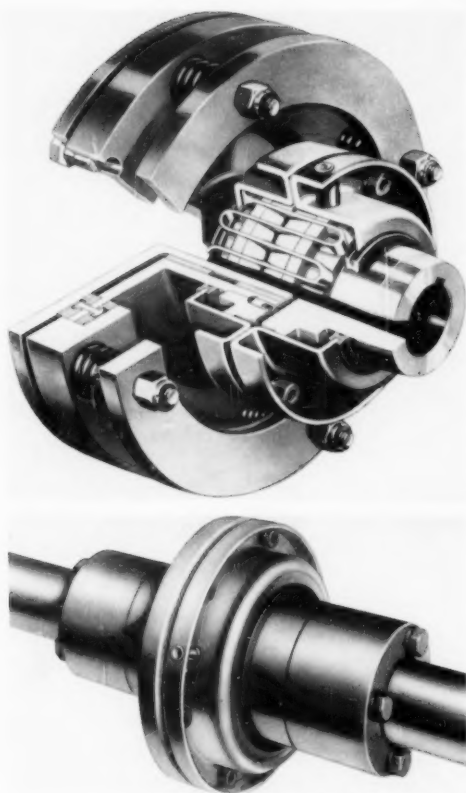
Vertical Type

Some types of standard "stock" couplings can be operated in either the horizontal or vertical position. One which was specially designed for operation in the vertical position only is illustrated in Figure 22E.

Controlled Torque

An example of this type coupling is illustrated in Figure 23A. By proper selection of adjusting springs

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Courtesy of The Falk Corp.

Figure 23 — (Upper) A controlled-torque flexible steel member coupling. (Lower) A similar type coupling especially suited to installations where it would be undesirable to disturb the connected machines.

and adjustment of the spring holder bolts, the amount of torque, transmitted by the friction lining on the controlled torque sleeve, can be varied and adjusted to a given value. Thus, it will prevent transmission of dangerous shocks, limit the overload and eliminate the breaking of shafts if jamming of the driven equipment should occur.

Spacer Type

This type coupling is illustrated in Figure 23B. It is used for the simple installation and removal of a flexible coupling where it is undesirable to move the connected units.

Flange Type

Where space limitations are severe, the close-coupled double-engagement Manger type flange coupling illustrated in Figure 24 may be used. It is bolted directly to a flywheel, brake drum or similar

mechanism, occupies less than half the space of the usual coupling and requires no dummy, pilot or stub shaft.

SEALS

Seals used in lubricated flexible couplings serve two very important functions, namely to prevent the lubricant from leaking out of the coupling and to keep extraneous foreign material from entering the coupling.

There are several types of seals in common use today which will be briefly described and illustrated in the following sections:

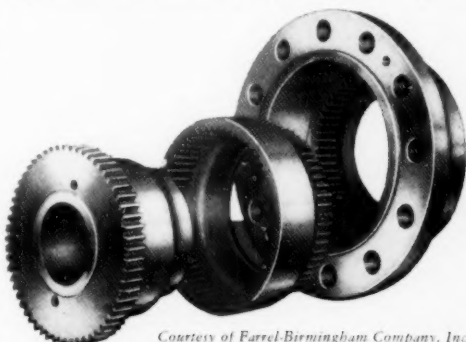
1. Labyrinth Or Rocking Sleeve Bearing Type Seal.

This is illustrated in Figure 25. This seal commonly used on gear type couplings has no non-metallic parts and thus is unaffected by high temperatures. It depends on its configuration and the very low clearances, a few thousandths of an inch, between the rocking sleeve and gear hub to prevent lubricant leakage. Oil or grease may be used as the lubricant with this type seal. In either case, the lubricant actually helps form a more effective seal with grease probably providing the better seal. This is in line with present day practice of generally using grease in gear type couplings.

This type seal is considered by some as being more of a dust ring rather than an actual positive seal. Although some lubricant leakage may occur under some adverse conditions if lubricant level is too high, couplings equipped with this type seal have generally given satisfactory service for very extended periods of time without relubrication, loss of lubricant or any indication of abnormal wear due to the entrance of extraneous foreign material.

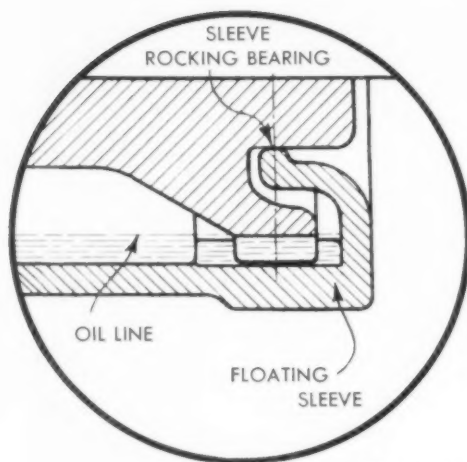
2. Metal Conformable Piston Ring Type Seal.

As illustrated in Figure 26 this seal consists of a segmented conformable piston ring with a garter



Courtesy of Farrel-Birmingham Company, Inc.

Figure 24 — Exploded view of a double engagement gear type coupling which requires minimum axial space.



Courtesy of Koppers Co., Inc.

Figure 25 — Labyrinth type seal.

spring fitting into a groove in its outer circumference to hold it snugly against the gear hub. As illustrated in Figure 9 the piston ring fits into a groove in the hub thus forming an effective seal unaffected by high temperature. This type seal is also available made of non-metallic materials, usually rigid type plastics.

3. Non-Metallic Seals (Synthetic Seals).

Prior to World War II leather, felt, cork and impregnated fabrics or packings were used primarily as seal materials that contacted lubricants. Since the last war various synthetic rubbers have come into more extensive use.

During the past decade considerable development work has been done on improving synthetic rubber materials for use in seals that come in contact with lubricants. Very briefly, it was found that the urethanes, Buna-N, polyacrylates, silicones and nitrile type rubbers are much more suitable for seals because of their better compatibility with lubricants. This compatibility becomes increasingly important at the higher operating temperatures up to 300°F.

In addition to the development work on improved synthetic rubber materials for use in seals extensive development work has also been done on the most suitable geometric configuration to use for given types of applications. A common O ring and solid rectangular cross section have been used. In addition cross sections in the form of an H or T and various lip-type and so-called quadri rings and rising O rings have been used where a greater degree of flexibility or movement are required. Five of these are schematically illustrated in Figure 27.

Figure 28 illustrates a gear coupling with another type of synthetic rubber seal.

SERVICE PROBLEMS

In most normal service installations where flexible couplings are installed and operated according to manufacturers recommendations, and reasonable lubrication and preventive maintenance practices are adhered to, long periods of completely satisfactory performance are experienced. However, due to certain unpredictably severe and uncontrollable conditions, service problems do exist: probably the two most common are leakage of lubricant and wear.

Lubricant Leakage

Since adequate lubrication is very essential for a flexible coupling depending for its flexibility on the relative movement between the contacting surfaces of the rigid components comprising the coupling it is very important that the lubricant is not lost. There are a number of conditions that can cause or contribute to lubricant leakage. Any one or a combination of two or more of the following more pertinent conditions can cause excessive lubricant leakage.

1. High Temperature

Operation of couplings at temperatures higher than recommended can cause lubricant and seal deterioration with resultant leakage.

2. High Speeds

Operation at excessively high speeds or speeds higher than the coupling design was intended for



Courtesy of Koppers Co., Inc.

Figure 26 — Metallic conformable piston ring type seal.

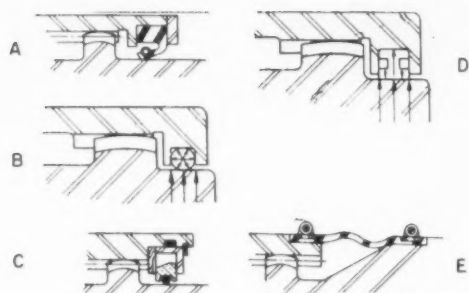


Figure 27 — Schematic of several types of synthetic rubber seals showing (A) lip (B) "O" Ring (C) rising "O" ring (D) "H" or "T" shape (E) boot with garter springs.

can result in lubricant loss. The maximum permissible speed for a coupling is dependent on its size since centrifugal force at a given RPM increases with the radius or diameter of the coupling. This can be of particular importance in grease lubricated couplings since oil separation from the soap in the grease can result in and cause loss of lubricant and in some instances actual failure of the coupling.

3. Poor Seals

Use of improperly designed seals or gaskets can result in lubricant leakage. Similarly using incorrect materials for making the seals can lead to deterioration or severely worn seals due to too long exposure, to too severe conditions and will result in leakage. In order for seals or gaskets to do an effective job of lubricant retention it is important that caution be exercised so that the metal surfaces of the covers or flanges contacting the gasket or the metal surface contacting the seal are not damaged in any way.

4. Incorrect Lubricant

Use of too low viscosity oils for the operating conditions or use of an oil for a coupling designed for grease lubrication can cause leakage.

Wear

Wear is generally the main reason for replacing a flexible coupling either at the incipient failure stage due to poor operation because of excessive clearance and noise or finally at the point where complete failure has occurred as a result of excessive wear. Several factors can contribute to or cause excessive wear. Probably the more important factors include the following.

1. Overload

Use of a coupling too small for the load to be transmitted generally results in either excessive wear, eventual failure or if it is sufficiently overloaded very early complete failure due to fatigue.

2. Excessive Misalignment

For most flexible couplings, and particularly the articulated joint type, when operating under conditions of misalignment greater than recommended for the coupling design, the load is carried by only a small portion of the load carrying elements rather than distributed evenly over all the elements. The resulting increased unit loading together with the greater amount of relative movement between the moving parts also caused by excessive misalignment will cause high rates of wear and short coupling life.

3. Inadequate Lubrication

Use of lubricant with too low a viscosity for the operating conditions encountered or lubricants with insufficient lubricity, load carrying ability and anti-wear characteristics can accelerate the rate of wear. Conversely lubricants with good characteristics in these respects can minimize the rate of wear and greatly prolong the life of a coupling.

4. Fretting Wear

It has been theorized that in flexible couplings under many normal operating conditions some of the conditions exist which are very conducive to fretting type wear. The pertinent items included here are small relative movement of contacting parts at high unit loads and under conditions of boundary lubrication at the loaded surface. Unfortunately when failure occurs or abnormal operation is noticeable due to excessive wear, the usual fretting debris and other characteristics have been destroyed. However, there is some indirect evidence that some of

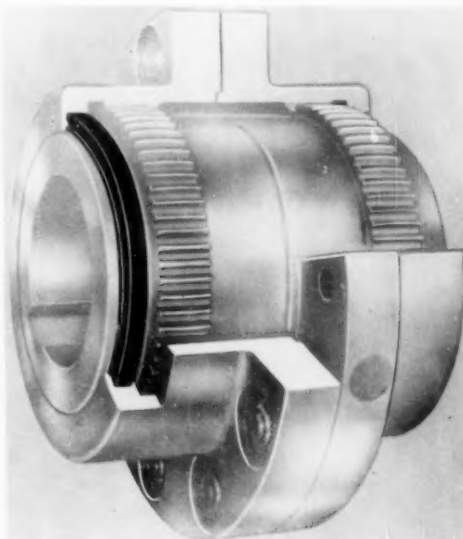
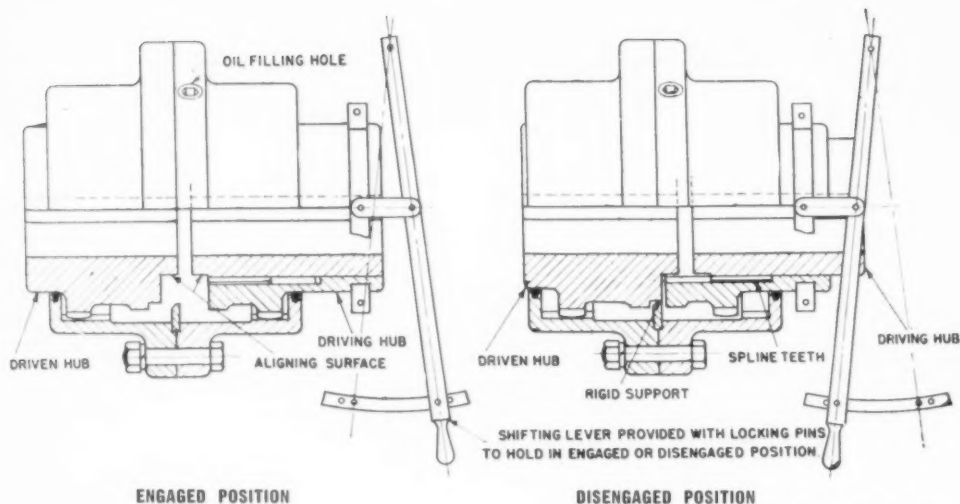


Figure 28 — A gear coupling with resilient moulded seals.

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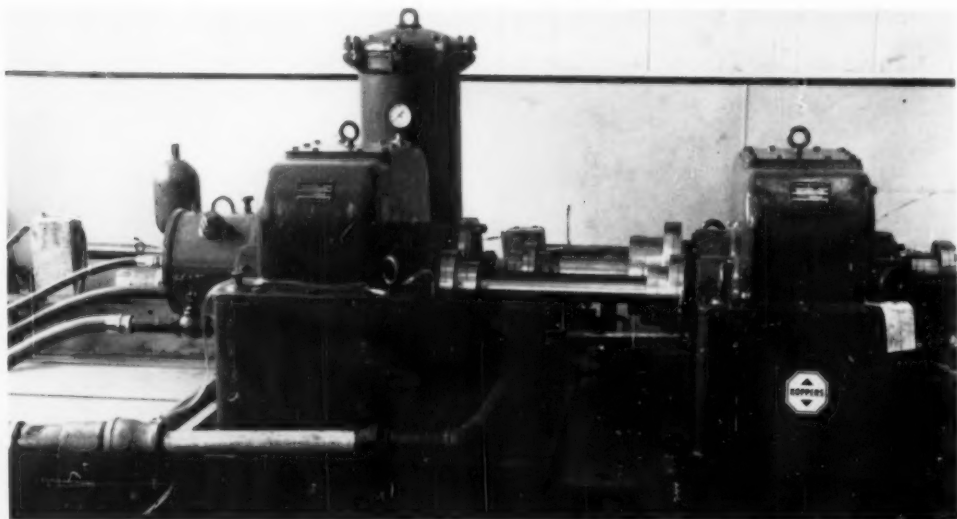
Courtesy of The Poole Foundry and Machine Co.

Figure 29 — A lever-controlled disengaging type gear coupling.

the failures and severely worn couplings may have started from fretting type wear.

In laboratory tests conducted on specimens of coupling materials under simulated service conditions the wear patterns obtained in short duration tests duplicated those observed in service.^{11,12} In the laboratory tests the "worm track" type wear was observed which is indicative of the advanced stages

of the wear phenomenon known as fretting or galling. In addition some of the conditions such as surface treatment, hardness, and lubricants normally considered to be effective in reducing fretting wear were also observed to be effective in reducing wear in laboratory tests. In line with the foregoing some of the practices generally found effective for relieving fretting type wear have also improved flexible



Courtesy of Koppers Co., Inc.

Figure 30 — A "four square" high-torque laboratory coupling test machine.

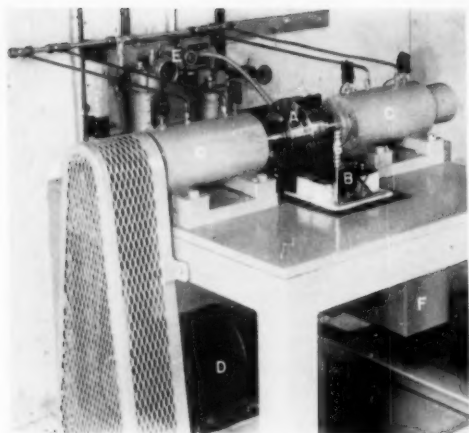


Figure 31 — A high-speed high-temperature laboratory coupling test machine.

coupling life in service, particularly under the more severe conditions. These practices include the following:

1. Submerged or flood lubrication with lubricant of maximum feedability.
2. Continuous or frequent relubrication to flush out accumulated iron-oxide debris.
3. Rubbing surfaces hardened by suitable methods.
4. Increased amplitude of oscillation thereby increasing the amount of fresh grease or lubricant dragged into the rubbing areas.

LABORATORY TESTS

As in many industry lubrication problems, it is necessary to utilize various laboratory tests. These are comprised of two general types, the physical-chemical and performance tests.

Physical-Chemical Tests

Similar to most lubrication problems, the normal laboratory tests for determining physical characteristics of oils and greases such as viscosity, pour point, gravity, penetration, melting and dropping point, etc. are used for product identification and recommendation.

In addition work has been conducted on other special tests in an effort to better predict performance of lubricants for flexible couplings. Although it is difficult to obtain sufficient service data to show a good correlation between the standard EP and anti-wear laboratory bench tests there is considerable evidence that under the more severe operating conditions lubricants having good EP and anti-wear characteristics give better performance than those that do not. This is particularly true in the lubrication of gear type couplings.

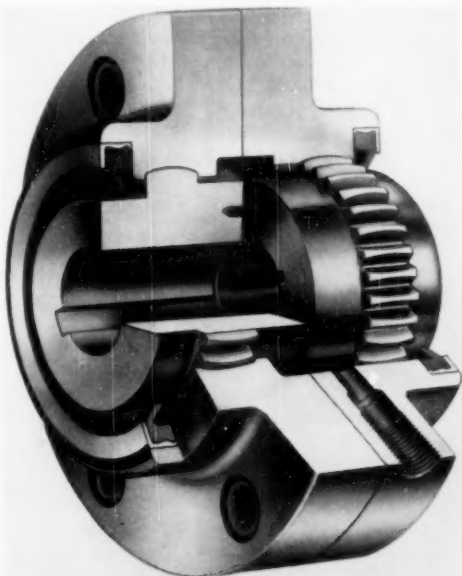
As indicated earlier on grease lubricated cou-

plings operated at very high speeds difficulties can be encountered due to oil and soap separation with resultant oil leakage and eventual failure due to lack of adequate lubrication. In highly accelerated laboratory centrifuge tests run at conditions to give centrifugal forces between 30,000 and 36,000 times the force of gravity it is possible to show differences between different types of greases so far as their ability to prevent oil and soap separation is concerned. Some information is also available to indicate that the operating temperatures may affect this characteristic differently on the various types of products. For purposes of comparison an industrial high speed gear coupling for a $2\frac{1}{2}$ inch shaft, having a pitch diameter of 5 inches and operating at 9000 RPM would produce a centrifugal force in the range of 5,000 to 8,000 times the force of gravity.

Although preliminary laboratory results are encouraging, it is difficult to obtain adequate service data to determine if a sufficiently good correlation exists between centrifuge tests and service performance to use this type of test to better predict performance of greases in service. Even though considerable work has been done in this general area, additional research is required to better establish the usefulness of such tests.

Performance Tests

In further effort to better predict the performance of flexible couplings and lubricants used in



Courtesy of Farrel-Birmingham Company, Inc.

Figure 32 — A general purpose crowned-gear tooth coupling with resilient lip type seals.

them under the various service conditions, so-called "simulated service" or "performance" tests have been developed for laboratory use. In these tests flexible couplings are operated under closely controlled conditions similar to the conditions of operation in actual service. Suitable instrumentation and control equipment are used to determine the pertinent operating conditions such as temperature, speed, load, misalignment, etc. and control them at the desired levels. Provisions are also made to vary each of the main operating conditions independently of the others. Examples of this type laboratory equipment are illustrated in Figures 30 and 31.

Although performance tests have the advantage of providing information on the actual equipment and conditions used in service they also present certain problems and disadvantages. Probably the greatest problem presented by tests of this type is determining the specific operating conditions to use in order to obtain the most meaningful and reliable information. If service conditions are duplicated exactly the length of the performance test may become excessively long and costly and thus, impractical. Therefore, it becomes necessary to accelerate the tests by increasing the severity of some of the test conditions. However, caution must be exercised to not over accelerate the tests to a point where the test results will not correlate with service. It generally requires considerable experience with such tests to establish useful and reliable correlation between tests and service performance. It is usually found particularly difficult to obtain reliable service performance information on flexible couplings since it requires a costly shut-down of equipment in which the flexible coupling is only a small part for even intermediate inspections. Shut-down for change of couplings and control of conditions is even more costly and difficult.

SIMPLIFIED LUBRICATION AND MAINTENANCE

Because of the many uses, the wide variation in operating conditions to which flexible couplings are subjected, and the importance of lubrication to their performance it would be impossible to select one lubricant that would be suitable for all applications. In line with the trend toward simplified lubrication in many plants it could be indicated that in the great majority of flexible coupling installations a good grade of grease of the multi-purpose type generally recommended for industrial bearing lubrication is satisfactory and generally the preferred lubricant. Furthermore, in line with simplification a lubricant used on other parts of the equipment for example the bearings nearest to the coupling is probably satisfactory in the great majority of cases. It has been aptly stated that having lubricant present in a coupling at all times is usually much more impor-

tant than the specific characteristics of the lubricant.

For unusual operating conditions such as abnormally high speeds, loads, temperatures, high misalignments, etc. lubricants with special characteristics may be required. In such cases recommendations of the coupling manufacturer should be followed or advice from a lubrication engineer based on his experience on the same or similar equipment in other installations may be highly desirable.

Periodic inspection and lubrication whenever equipment is shut down for other reasons is a good practice until experience has established longer lubrication intervals to be satisfactory. In addition, considering lubrication as a part of good maintenance practices and requirements of the overall machine will assist greatly in assuring adequate lubrication and good performance. That is, if the lubrication of a coupling and machine can be timed and attended to concurrently the operator will probably do a more conscientious job on both.

SUMMARY

Although developments and improvements in design and manufacture of couplings in recent years have led to use of flexible couplings for conditions of greater misalignment for most normal installations it is still considered good practice for the alignment of the connected shafts to be made as perfect as feasible consistent with cost and other factors to assure optimum performance.

Even though there has been a trend in recent years to the use of a grease of the all-purpose or multi-purpose type for most of the normal flexible coupling installations there are still many applications that require special lubrication considerations, both with respect to method of lubrication and special characteristics of lubricants. Developments in lubricant additives to further improve some of the special characteristics such as; EP, anti-wear, high temperature stability, etc. of lubricants are continuing.

Most of the developments and improvements in flexible couplings in recent years have resulted from the cooperative efforts of the coupling manufacturer and operator assisted in some cases by the lubricant supplier. Continued cooperation in this manner will assure the equipment users of satisfactory and further improved performance of flexible couplings in the future.

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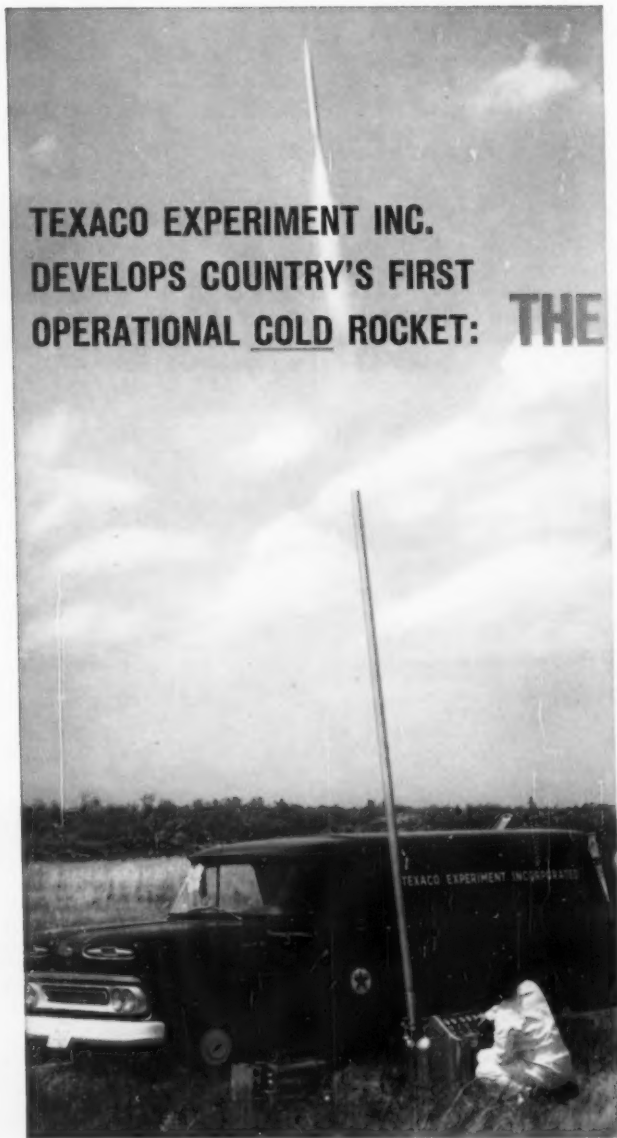
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